Superconductivity

A Comparative Equivalence

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Abstract

Here is proposed a simple thought experiment, yielding insight into the microscopic properties of superconductors. The basic proof is a proof by contradiction based off energy conservation and the absolute or complete diamagnetism of superconductivity, with relativistic arguments. It is argued that an additional factor accompany superconductivity that is the complimentary attribute of general covariance as it applies to quantum mechanics. This additional covariance proves necessary to explain several attributes of superconductivity.

Introduction

The High Temperature Superconductors consist of planes of antiferromagnetic spin texture that when doped create a material capable of phase transitioning into a superconducting state. From this it is reasoned that a spin field must be incorporated into the model. The generation of a spin field, and the interaction of the net momentum with the electromagnetic field are then considered, as well as the implications for a covariant generalization of quantum mechanics in the setting of this field of spins, with the question in mind of: "How does the eigenstate condition change in the context of a model which incorporates a field of spin and an electromagnetic interaction?" This is shown via the covariant differential to lead directly to the principle of a reversed potential between particles interior to a superconductor. From this it is argued that an effect of mutual and relative curvature arises between charged particles in the spin field by way of the electromagnetic interaction. As a whole this description is predictive of pairing, the diamagnetic effect, the condition of zero magnetic field interior to a superconductor, and the gap. It is established that the states internal to a superconductor are in inertial freefall with respect to the spin field and under the influence of the electromagnetic potential. From this, we must move to a new viewpoint where the variables of spin curvature momentum and orbital momentum are treated in a manner such that they are in a non zero-sum relationship. The attractive interaction in superconductivity and gap is motivated by the displacement of and reciprocation of quantum mechanical particle only orbital energy momentum and spin curvature energy momentum under comparison of different accelerative frames with the presence of an electromagnetic potential. The frame difference under acceleration by the electromagnetic field is found to amount to the effect of a lowering and raising operator under the covariant two particle Dirac equation in the presence of a spin field, which explains the appearance of a pairing gap, while the condensation gap is given by the reciprocal process of motion of charge pairs apart.

Guiding Philosophy of Theory

It is reasonable to take as valid that the only things within physics that are knowable, in a very certain and real sense, are by way of differences in quanititative measure according with differences in qualitative description. In this, knowing correctly the interpretation and range of validity of a given physical description of reality is essential for an understanding of its possible predictions. Within physics, the only consistently formulated theory of gravity of space and time in four dimensions is general relativity and it is based upon only two givens, that there are no absolute frames of reference and that the speed of light is an invariant with respect to all observers. To be compatible with the existing theory of general relativity, therefore any theory of quantum mechanics must be consistent with this principle of relativism, from which will spring its qualitative and measurable effects on quantitative measure. To bring these theories into contact the method chosen is that of adopting the essential qualitative features of general relativity and applying them to the formalism of quantum mechanics. This is justified by the reason that without this quality the theory of quantum mechanics would be rendered inconsistent with general relativity by artifacts of descriptive dependence. As a consequence, one finds the theories as complimentary in quantitative difference, and reciprocal in qualitative measure.

Superconductivity

The superconductivity described here is that of the high temperature superconducting compounds. These compounds illustrate very high critical temperatures and are usually spin based systems, found by doping oxygen or another atom into the material. This oxygen in certain materials known as antiferromagnets causes the planes of spin which are predominantly electron occupied to adjust such that they give up electrons to the oxygen doped into the material off of the plane, leaving behind holes in the antiferromagnetic plane.

These holes fall into pairs and condense under the right conditions of temperature and pressure to form a state of superconductivity. This is explained in the conventional theory by the presence of a 'gap' to excitations from a state with zero scattering, and hence zero resistive losses to the flow of a current. In addition to this infinite conductivity under certain conditions, there exists a quantum mechanical effect known as the "Meissner effect", whereby a superconductor will expel any existing magnetic fields once transitioning to the superconducting state.

This is not the same as simply infinite conductivity because if this were all that held true then a material cooled to transition in a magnetic field would retain currents and hence there would be a persistent magnetic field interior to the superconductor. However, what really happens is that the field is completely expelled. The magnetic field being zero interior to the superconductor is defintional of the superconducting state through the Meissner effect.

Antiferromagnetic Materials

An antiferromagnetic material is a magnetic material that is defined by two sublattices of oppositely pointing magnetic moments that when perturbed convey magnetic moment waves which are capable of traversing from one side of the material to the other. Antiferromagnetic, as well as magnetic materials, (distinguished by two or one predominant Neel vectors) depend not on the alignment of magnetic moments, as one would presume naively, but because this interaction is too weak and cannot explain the observed Curie temperature (the temperature at which the material loses its inherent magnetism). From this, the exchange interaction is the real reason explaining the magnetic interaction and persistence of a magnetic field to high temperatures.

The exchange interaction is an interaction whereby electrons are shared in covalent shells among the outer layers of their atomic models. These orbits accompany more than one atom, and the electron is said to be shared. When this occurs, electrons can couple to the dynamics of either atom for they are coexistent on multiple atoms. Due to the Pauli exclusion principle, they may not occupy the same atom at the same time with identical quantum numbers. One of these numbers, the spin, does accord with the magnetic phenomenon and gives rise to an accompanying magnetic field on the site the electron is located on. But, as for the nature of their spin alignment, there is a small or weak magnetic contribution and a large or strong coulombically produced exchange. This coulombic exchange is the integral of the antisymmetric contribution from occupancy on the same atom with opposite spins, which gives rise to antiferromagnetism. In other models, the non-valent electrons laying underneath the sea of mobile and valent electrons give rise to cooperative ferromagnetic alignment from on site repulsion. This means the atoms only possess for our interests one electron per site when considered as a ferromagnet, but when considered as an antiferromagnet there is at least a duplicity to give rise to mutually defined directionality. What distinguishes a ferromagnet from an antiferromagnet is not only this mutual versus single electron occupancy of atoms, it is the fact that there arise two sets of Neel vectors. Neel vectors in space are directions which account for the predominant magnetic moment of a sublattice. These are associated in a checkerboard pattern with the underlying lattice and give rise to a different ground state from that of the ferromagnet, which has but one aligned Neel vector per domain.

Thought Experiment

The following thought experiment illustrates that if the Meissner effect is complete, then the foregoing conclusions are valid and apply to superconductivity.

The first hypothesis is:

Hypothesis of Superconductivity I: *The superconductor magnet force to gap relationship is indistinguishable from the gravitational force to mass relationship.*

If the gap Δ is equivalent to a rest mass energy then it is invariant with respect to all observers and is expressible as the inegral of a field of curvature:

$$\Delta = \lambda \int_{\tau} \gamma^{\mu} \Lambda_{\mu} dx^{\mu} \tag{1}$$

With λ a constant and:

$$\Lambda_{\mu} = \partial_{\mu} \log \Lambda_{\mu}^{\nu} \tag{2}$$

A curvature field of the Lorentz transformation that has spatiotemporal dependence. This quantity is defined such that γ^{μ} is the Lorentz factor of weight associated with gravitational freefall, and Λ_{μ} is the inverse factor corresponding to the length contraction and time dilation of space.

For if instead Δ is not equivalent to a rest mass energy then, it is frame dependent and it would vary with the structure of spacetime and increase or decrease with the metric under inertial freefall. The center of mass would no longer be preserved covariantly in general but would exist with a varying gap for different inertial rest masses (Galileo). So it must be that Δ is equivalent to a rest mass energy and invariant and it is conserved under inertial freefall, although the factor γ^{μ} may vary with kinetic motion. Additionally, because the field energy goes into the motion, the energy mass content remains the same by energy conservation in an inertial freefall experiment with magnet and superconductor under mutual repulsion.

Hence the hypothesis follows that:

Hypothesis of Superconductivity II: *The field of the Meissner effect is reciprocal to the field of factors of γ from general relativity so as to render Δ and the total mass energy covariant and the Meissner effect complete.*

Consider that the scenario envisioned is one where particles A and B, a superconductor and magnet, move apart freely in space. It has been shown that the gap, or Δ, can be considered a rest mass energy with no dependence on the curvature of spacetime. If we consider the two particles then; from the rest frame perspective of particle A, particle B appears to receed with its own factor of relative γ; and from the perspective of particle B, particle A appears to receed with its own factor of relative γ. In their own internal frame description, γ for particles A and B are equal to 1 and, external to this frame, they carry γ factors nonequivalent to unity.

The hypothesis follows that:

Hypothesis of Superconductivity III: *The change in inertial mass energy content is indistinguishable from the change in potential energy mass content for the mechanism of superconductivity.*

To prove these hypotheses, consider a magnet and superconductor in alignment with the direction of gravitational freefall and under gravitational freefall. If M is for the magnet and S is for the superconductor, which is at rest in its comoving frame of inertial freefall, the electromagnetic four potential of the superconductor is some transformation of the electromagnetic four potential of the magnet:

$$A_{\mu}^{S} = \Omega_{\mu}^{\nu} \Lambda_{\nu}^{\mu} A_{\mu}^{M} \tag{3}$$

Our intention is to show that this relationship must hold true by contradiction with the Meissner effect and energy conservation simultaneously. If there is no equivalency we could attibute outside factors, if there is equivalency then Λ and Ω show equivalent and opposite curvatures. Ω is the currently unknown factor we attribute to the effect of magnetic mirroring. In the rest frame of the superconductor there is a quantity which exists if the magnet approaches the superconductor with a differential as:

$$\partial_\mu \log(A^S_\mu) = \alpha_\mu \tag{4}$$

And we separately analyze the partial differential of the other side of the equation to show they must be equivalent:

$$\partial_\mu \log(\Omega^\nu_\mu \Lambda^\mu_\nu A^M_\mu) = \beta_\mu \tag{5}$$

If it does not hold true that these are equivalent, then these differentials would differ and the integration constant would be potentially nonzero.

An electric field does not exist from motion because the relative velocity is coparallel with the magnetic field. If one occurs from change in the magnetic field in time then it would either be the case that the magnetic fields are equal and opposite and there is no electric field, or they are not equal and opposite, and there is an electric field. Energy conservation implies that α_μ and β_μ change in such a fashion so as to preserve the electromagnetic field energy which is conserved by definition in the rest frame. But with one becoming smaller, and the other larger if an electric field existed, the Meissner effect would be violated. Hence it cannot be the case that $\alpha_\mu \beta^\mu = C$, a constant, with $\alpha_\mu \neq -\beta_\mu \neq 0$.

The Meissner effect implies that $\alpha_\mu = -\beta_\mu$, and that these could be nonzero, but they cannot be nonzero if energy conservation is to hold true in the rest frame since then the total energy content would be changing. Since there is no electric field and the magnetic field energy would change in the rest frame by the dot product of their magnetic fields, it cannot be the case that these are nonzero. Consequently this also implies the integration constant is zero. Thus the Meissner effect and energy conservation can be mutually satisfied if and only if:

$$\alpha_\mu = \beta_\mu = 0 \tag{6}$$

Identically, and with an integration constant of zero to produce:

$$A^S_\mu = \Omega^\nu_\mu \Lambda^\mu_\nu A^M_\mu \tag{7}$$

Now we shift our discussion to determine the nature of Ω, which is a transformation related to the infinite magnetic mirroring. We posit that a superconductor and magnet are at rest relatively in an noninertial frame of the gravitational field of the Earth, an electromagnetic pulse traverses the medium of air between them vertically, and we analyze a series of snapshots of the electromagnetic wave between them.

Taking as an arbitrary initial configuration that the electromagnetic field of the magnet is some function of distance from the magnet and begins to traverse the medium of air downwards at the speed of light as confirmed by relativity, it will travel faster than the normal speed of light in vacuum by a proportionality of the relativistic factor:

$$\gamma \tag{8}$$

This will be a function of distance due to the curved nature of the spacetime of in the vicinity of the Earth and its accompanying gravitational field. Additionally, there is a slowing relative to the normal in vacuo speed of light due to the presence of air, which we will neglect, presuming we are doing our experiment in a vacuum. The magnet would ordinarily fall in the presence of the gravitational field, but it is supported by the superconductor which we take to be additionally supported by a table with a vat of liquid nitrogen that is sufficient to cool the superconductor to superconducting capability.

The nature of a superconductor, which is an experimentally verifiable phenomenon, is to exhibit a Meissner effect whereby all magnetic fields are actively expelled from the superconductor such that the magnetic field interior to the superconductor is zero. This is supported by the notion that it is also a perfect conductor, and there exist superconducting super currents on the surface of the superconductor which shield the interior from a magnetic field penetrating the superconductor in the type one normal phase.

For now, we will exclude the type two superconducting phase from discussion, where the magnetic field can penetrate the superconductor. In the normal phase, the superconducting Meissner effect is the effect that when cooled, a superconductor is not only a perfect conductor, but a perfect diamagnet, because the magnetic field will be expelled from the interior, and not left trapped, as it would with only a perfect conductor. Taking the superconductor and magnet to levitate is an indication of this complete field repulsion of diamagnetism, as we know two opposed magnets repel. Taking the magnet to be with a magnetic moment of:

$$\mu \tag{9}$$

The falloff in space is described by a function which incorporates the direction of freefall as $\hat{z}$:

$$\mu f(z)\hat{z} \tag{10}$$

Where $\hat{z}$ is the normal direction in which the magnetic field is pointing and the direction in which the magnetic and superconductor are separated vertically in space. For now, we assume the experiment could be performed with a perfectly small point like magnet and point like superconductor. The magnetic moment of the superconductor is another function, now displaced in space, but, it is a mirrored moment, critically at the location of the original magnet, because a perfect conductor will create super currents that mirror the magnetic moment. Besides simplifying our discussion, it can be easily seen that only this mirroring of the magnetic moment can create complete field cancellation in the interior of the superconductor. Thus the magnetic moment of the superconductor is to exhibit a displaced magnetic moment at the position of the magnet of:

$$-\mu f(z)\hat{z} \tag{11}$$

This is the same as if it were to have the opposite direction or the opposite moment. The magnetic field of the magnet remains as its usual moment and is not diminished by this effect, but there is still the behavior of the mirroring field which concerns us. For the light of the electromagnetic wave that traverses the medium completes two trips in this effective loop through space and time. A snapshot view illustrates that first, the magnetic moment is made larger by a relativistic factor of:

$$\gamma \tag{12}$$

This occurs from transformation via its representation at the position of the superconductor, and then is made smaller by this same factor on the rebound. However, the light that traverses the medium when taken from the viewpoint of an observer that is distant is this value. The given fields are not made any larger or smaller locally in the non-inertial frame of free fall with the magnet and superconductor. If we were to remove the support, and allow the magnet and superconductor to undergo inertial free fall, we would encounter a different set of snapshots. In the viewpoint of a distant observer viewing the free fall in comoving coordinates, the magnet will exist with a magnetic field:

$$\mu f(z)\hat{z} \tag{13}$$

And the superconductor with a magnetic field:

$$-\mu f(z)\hat{z} \tag{14}$$

However, we know that the factor of γ is changing at the same time. Comparatively, the magnetic field of the magnet will become in our representation viewing the system from afar:

$$\gamma\mu f(z)\hat{z} \tag{15}$$

While the magnetic field of the superconductor will become in our representation viewing the system from afar:

$$-\gamma\mu f(z)\hat{z} \tag{16}$$

This is remarkable, because somehow the magnetic field of the magnet has been affected so as to become larger by super currents from a comparatively smaller source. Taking snapshots of viewpoints, first we have a magnetic field of the following from the magnet at its location, equation (16). The distance between the superconductor and magnet is as a given:

$$R = cdt \tag{17}$$

While the distance viewed from the distant observer is getting progressively smaller due to length contraction by a distance also equivalent to, as viewed by the local observer:

$$r = vdt \tag{18}$$

Comparatively, what is witnessed is a force acting through a distance R from the distant observer and through a distance r from the local observer. This is equivalent to a contraction of the electromagnetic field with each successive bounce of the electromagnetic field as the superconductor and magnet fall together. This is the ratio:

$$\frac{r}{R} = \frac{vdt}{cdt} \tag{19}$$

Including for the sake of placing these in the same external observer from afar viewpoint we must replace the velocity with the boosted velocity, while the time dilation factor is left common for we compare these in the same present location:

$$v \to \gamma v \tag{20}$$

What we are left with is the comparative ratio of strength between each bounce in each snapshot viewpoint of reflection of the magnetic field via light between the magnet and superconductor within the comparative viewpoint of an observer from afar versus the local observer. Summing over the infinite reflections to find the potential energy produces:

$$\begin{aligned} \vec{B}_M \cdot \vec{B}_S &= -\sum_{n=0}^{\infty}(-1)^n \mu^2 f(z)^2 \gamma^2 (\frac{v\gamma dt}{cdt})^{2n} \\ &= -\mu^2 f(z)^2 \gamma^2 \frac{1}{1-\frac{v^2}{c^2}\gamma^2} \\ &= -\mu^2 f(z)^2 \gamma^2 \gamma^{-2} \\ &= -\mu^2 f(z)^2 \end{aligned} \tag{21}$$

Where the alternating series is from the reflection of each contribution under which the sign of the magnetic field changes. The per superconductor or magnetic moment field is then:

$$\xi = \pm \mu f(z) \hat{z} \tag{22}$$

This vindicates a viewpoint that the magnetic moment is unaffected by gravity while in inertial free fall because it is a quantum phenomena. Not only does this illustrate that inertial considerations apply to magnetic superconducting levitation and other quantum phenomena independently of gravity, it says that these effects may be subsumed into the architecture of general relativity for a system as if quantum mechanics remains inertial while undergoing inertial free fall with a different metric.

Or, analogously moving back to the rest position in non inertial levitation, this phenomenon is also inertially supported. So, for all considerations quantum mechanics can be considered to be an inertial phenomenon above and beyond any other considerations. Indeed in this experiment the result is that there is no effect of general relativity upon the quantum system, for the transformation is removed. But, $\beta = \gamma^{-1}$ which cancels the relativistic γ of relativity is associated with Ω.

This points to a given transformation from the perspective of general relativity that when invoked if we were to apply general relativity to quantum mechanics we would have to immediately reverse our direction and apply the inverse transformation upon all quantities. This has the side effect of meaning that quantum mechanics is inherently a theory which embodies the inverse of the transformations of general relativity under the same auspices of considerations of inertia. For instance, a magnet and superconductor that are stuck together by the flux pinning will illustrate inertial evolution analogous to the moon about the Earth in parallel analogy to general relativity.

The two theories are such that quantum mechanics remains in its ultimate state free from coordinate transformation. Saying this embodies a translational motion for inertia in circumferential motion is the same as saying the inverse of the transformation provided by general relativity as applied to quantum mechanics is the same as the forward transformation provided by quantum mechanics upon quantum mechanics. Furthermore, this result shows that the well known Meissner effect is an illustration of the general covariance of quantum mechanics. This results in two viewpoints;

A:) In the first, the field transformations are reciprocal such that in any rest frame the energy momentum remains as a constant by the requirement of the Meissner effect and energy conservation.

B:) In the second, the field transformation does not lead to a constant energy momentum of the bodies and the Meissner effect magnetic fields change in magnitude, but the global frame must change.

And this is a comparative type of equivalence to that of the well known general covariance, for it works reciprocally in quantum mechanics. The first can be seen as the internal rest frame description. The second can be seen as the externally viewed description. Yet, they are equivalent physically. This is the resolution of our hypothesis:

These two viewpoints are equivalent under equivalency of electromagnetic field potential mass energy lowering and inertial mass energy lowering.

Equation (7) indicates that Λ changes the slope of the function in time in inverse proportion to the change in magnitude from Ω. From this, the log derivative represents the functional argument of this scaling. Thus it is the functional argument of the boost. This is the very expression of curvature in our quantum system. For we may of course hold true that:

$$A_\mu^S = -A_\mu^M \tag{23}$$

From the very Meissner effect we started with. This is the expression of diamagnetism and is definitional of superconductivity. One could argue that inertially these must be two pure Lorentz-like transformations, but such is not the case in the noninertial levitation. For here the system is interacting, and we have no direct inverse for the transformation, although they form the identity. So we must hold as true that:

$$\partial_\mu \log(\Omega_\nu^\mu) = -\partial_\mu \log(\Lambda_\nu^\mu) \tag{24}$$

This allows us to reason that both Λ and Ω carry spatiotemporal dependence, and for the considerations of any mechanism of superconductivity there must be a curved representation for the variables of position and momentum in the uncertainty principle. We end with a conclusion regarding the mechanism of superconductivity:

Conclusion: *Quantum states and electromagnetic fields are subject to a quantization condition holding invariance such that they are relatively inertial with respect to each other's quantities in each other's frames. The reciprocal relationship between the magnetic field mirroring and field transformation from relativity is the very condition that they be mutually inertial within each others frames under inertial freefall or noninertial support, in confirmation of the application of general covariance to quantum mechanics. The effect of the transformation which is the Meissner effect is the instantiation of general covariance within quantum mechanics.*

Comparative equivalence is now an appropriate term for the coexistence of a principle of relativity in quantum mechanics and general relativity, and that the results of measurements do not depend on coordinate system transformations or displacements. In this, comparative equivalence can also be defined as:

Comparative Equivalence: *The physical results of differences in measure between an observer that is stationary & an observer that is in motion are physically real and measurable, however differences in the physical results of the process of measurement between an observer that is stationary & an observer that is in motion are unphysical & null.*

Review

We know from the theory of quantum mechanics that:

$$[p_\mu, x^\mu] = i\hbar \tag{25}$$

As x^μ is a position vector, it is noted that it accounts for distance in such a manner that the units of x^μ will scale contravariantly, meaning they describe a position for which length contraction is the determination of the unit of measure growing for x^μ and the object appearing smaller. As p_μ is a differential operator, it is noted that it accounts for the differential in such a manner that the units of p_μ will scale covariantly, meaning they describe a differential for which length contraction is the determination of the unit of measure lessening for p_μ and the object appearing to have smaller differential. If we perform a Lorentz transformation then the length will contract, the units of x^μ will grow, and that of p_μ will lessen. Thus the object will decrease in relative energy momentum with length contraction.

The assessment of the man in the tower is in agreement then between general relativity and quantum mechanics, as the object will be assessed to have a different and lower relative energy momentum when undergoing freefall at the surface of the Earth. In this, general covariance is consistent with general relativity and quantum mechanics. The energy momentum of a particle is covariant, and there can be an application of the equivalence principle to quantum mechanics. Why or how this is necessary is then a thing that we need from the general covariance of quantum mechanics as a given theory compatible with general relativity. The fact that general covariance applies to quantum mechanics has several marked consequences, one of which is that the Meissner Effect is the statement of the equivalence principle as it applies to quantum mechanics. This is the discovery of my paper, and it is consistent with general covariance by the above.

General Covariance

It is hypothesized by way of the equivalence principle that because gravitational mass is indistinguishable from inertial mass the eigenstate condition of quantum mechanics extends from local Lorentz invariance to the condition of general covariance for the comparison of states by taking the particles to be within inertial states.

The condition of inertial states however implies in the general relativistic setting that inertial mass is equivalent to rest masses for all particles undergoing inertial freefall, from which the condition of local Lorentz invariance can be derived. If the condition of local Lorentz invariance does not extend to general covariance by using the rest mass for inertial states under mutual interaction, the resulting theory would be inconsistent with general relativity.

To understand this imagine a wall in front of the observer with rest mass and zero momentum. If it were to be moving away from the observer then the question would be as to where the extra relativistic energy momentum comes from it has with respect to the observer. So as to not violate energy conservation this must be a matter of perspective, so the only objective physical description, given by the equivalence principle, is for it to maintain its rest mass in the ultimate viewpoint.

If quantum mechanics were then not subject to the same provisions of perspective, because the quantity of energy momentum would be different for the two theories, energy conservation would be violated. Hence it is true that mutual interactions are relatively inertial with the mass given by the rest mass and the application of general covariance to quantum mechanics is inconsistent unless inertial frames are used in which the mass is the rest mass.

The quantization condition that follows must extend from pure local Lorentz invariance in the local viewpoint to general covariance in the global viewpoint under consideration of the equivalence principle and utilize rest masses within inertial frames as the basis for all particle interactions.

Under these provisions as the equivalence principle must apply to quantum mechanics the expectation of energy momentum is therefore always lower for a quantum system with the inclusion of general covariance, where the quantization is with respect to the condition set by all relativistic factors returning to unity. Not only is this a comparison of the inclusion of general covariance to without it, it also represents a real energy momentum lowering because of the reality of the effects of general relativity with respect to measurement of a state so quantized to the rest mass condition and compared to the subjective viewpoint of an observer.

Justification; Energy Lowering

The energy momentum of a system is always measured as lower in total as compared to the sum of its individual parts because it is subject to general covariance and the equivalence principle.

To understand this it is relevant to review a few precepts of general relativity. Based on the theory of relativity, the condition is a given that energy momentum is observed as larger for a body in motion relative to an observer corelatively at rest measuring the rest mass energy of the object. What needs to be shown is how coordinate freedom by virtue of general covariance and the equivalence principle reduces to a lower energy momentum for a system as compared with the sum of the individual parts.

General relativity by the equivalence principle dictates that inertial mass energy is indistinguishable from gravitational mass energy. Therefore bodies of all masses fall at the same rate in a given gravitational field, because there exists universality to the rate of change of motion for any mass.

As gravitational mass increases, so too does inertial mass, on each side of the equation dictating force. Given this is true, locally there is no relativistic factor under freefall in its own given frame, and a body undergoing such motion is weightless to its self in the sense that it feels no gravitational field in its frame.

Coordinate freedom further implies from general covariance that physical laws are invariant, and gravitation is no exception, in that there exists universal freefall of all gravitational bodies. This means that the equivalence principle implies that there can exist no ultimate frame dependence for body body comparisons. As it can now be seen, the coordinate freedom of the system implies that the equivalence principle is a global principle, and its implication is that any frame dependence to the comparison of states is unphysical.

This reduces the problem of the extension of quantum mechanics from local Lorentz invariance of a locally flat quantization condition to the condition of general covariance for comparison of states in quantum mechanics. Coordinate dependence must disappear on the ultimate level, such that comparisons between states internal to the system are taken as within inertial frames with rest masses, so that the equivalence principle holds true ultimately and in general for both theories.

Therefore quantum mechanics would be inconsistent with general relativity if general covariance did not so similarly apply to the provisions of the mutual quantization condition between states under interaction. As a consequence, in the global viewpoint the relativistic factors are absent under state state comparisons within the system, yet there is the same phenomenon of energy dependence with respect to the subjective observer.

What is measured by an observer stationary with respect to the center of mass of the system is a physical energy momentum. With the given effects of the equivalence principle on the various parts of the system in relation to one another it is a lower energy momentum because it is determined by a viewpoint in relation to parts so mutually existent as to be within inertial states in relation to one another. Therefore, the system is always measured to have a lower energy as a whole compared to the sum of separable individual parts.

General Covariance of QM

In order for quantum mechanics to be consistent with accelerations as general coordinate transformations, it must hold true that the eigenstate holds an independent reality with respect to these types of transformations. For instance consider a two particle system. In order for the consistency of quantum mechanics under electromagnetic interaction, it must hold true that both states remain mutual eigenstates with respect to their frames of acceleration.

Any proof must be based on the supposition that the eigenstate remains an eigenstate for each particle with respect to all others under mutually accelerated motion. This holds, given that although it is true that locally in the frame of acceleration the eigenstate may be defined, it must also be an eigenstate with respect to other frames of reference, *and for the considerations of relativity may contain no frame dependence.*

Suppose in the frame of the particle ∂_μ is the basis of the operator for momentum. Then, $\gamma^\mu \partial_\mu$ is the relativistic operator for momentum and should be invariant under general coordinate transformations. This operates on ξ_μ, the wavefunction so that $\gamma^\mu \partial_\mu \xi_\mu$ is the relativistic energy momentum of the eigenstate.

If an only if this is an accelerated state does Λ^μ_ν as a transformation have a spatial and temporal dependence, in which case:

$$\begin{aligned} \gamma^\mu \partial_\mu \xi_\mu &\to \Lambda^\nu_\mu \gamma^\mu \Lambda^\mu_\nu \partial_\mu \Lambda^\mu_\nu \xi_\mu \\ &= \gamma^\nu (\partial_\nu \Lambda^\mu_\nu) \xi_\mu + \gamma^\nu \partial_\nu \xi_\nu \end{aligned} \tag{26}$$

And an extra term appears, which does belong to the same frame ν but which introduces a frame dependence to the derivative. In this case ξ is no longer an eigenstate with respect to the accelerated frame. Since:

$$\Lambda^\mu_\nu = \gamma^\mu \gamma_\nu \tag{27}$$

It is true that this can be accomodated by subtracting a term from the right hand side of the eigenstate equation for four momentum, or alternatively and equivalently adding a term which transforms reciprocal to the definition of the four momentum, thereby defining the *covariant differential.* Working out what the extra term means, it is equivalent to:

$$\gamma^\nu (\partial_\nu \Lambda^\mu_\nu) = \gamma^\mu \gamma_\mu \partial_\nu \gamma^\mu \tag{28}$$

In the frame of ν, or under transformation back to the frame of μ the term which must be added to ∂_μ to preserve the differential is:

$$\Gamma_\mu \equiv \gamma_\nu \partial_\mu \gamma^\nu \tag{29}$$

In conclusion, for quantum mechanics to possess no frame dependence for eigenstates, and for them to be mutually defined under interaction, the covariant differential defined by the following must be used for the energy momentum of the particle:

$$p_\mu = i\hbar(\partial_\mu + \Gamma_\mu) \tag{30}$$

From this not only follows the rule of differences in frame contributing to the localization in a zero sum fashion but that the separable parts of the momentum change as the following under a general transformation:

$$\partial_\mu \to \partial_\nu + \Lambda_\nu \tag{31}$$

$$\Gamma_\mu \to \Gamma_\nu - \Lambda_\nu \tag{32}$$

With:

$$\Lambda_\nu = \partial_\nu \log \Lambda^\mu_\nu \tag{33}$$

Eigenspinor Field Theory

Consider the general transformation of the spinor part of the wavefunction:

$$\xi_\mu(x_\mu) \tag{34}$$

The approach used is that of generating a field theory from a general transformation of a field quantity.

$$\xi_\mu \to \Lambda\xi_\mu \tag{35}$$

Here Λ is a 16 parameter tensor which represents the transformation upon a general wavefunction ξ_μ. The transformation Λ should not be confused with a Lorentz boost, it is a transformation of the field of spinors into itself and is an operator. It however carries analogous properties, for a rotation and a scaling of the spinors *is* equivalent to a *local* change in frame, however it does not arise by net global motion but instead by way of the evolution of the field of spinors. This can be written in general as:

$$\Lambda = e^{-ig\lambda_{\mu\nu}(x_\mu)\sigma^{\mu\nu}} \tag{36}$$

The spinors are rotated and boosted in the six possible directions given by the tensors in the transformation. Where g is a coupling constant and $\lambda_{\mu\nu}(x_\mu)$ parametrizes this transformation in space and time, while $\sigma^{\mu\nu}$ is a set of matrices corresponding to the commutator of the γ matrices, as in the following:

$$\sigma^{\mu\nu} = \frac{i}{2}[\gamma^\mu, \gamma^\nu] \tag{37}$$

What is important is that a *gauge* can be defined for this transformation, since it acts on a *field of spin*, as:

$$\partial_\mu \to D_\mu = \partial_\mu + \Gamma_\mu \tag{38}$$

With:

$$\Gamma_\mu \equiv \gamma_\nu\partial_\mu\gamma^\nu = \partial_\mu \log \gamma^\nu \tag{39}$$

Since this is the log derivative of the spin as a field, the transformation is as follows on the Dirac equation:

$$\xi_\mu \to \Lambda\xi_\mu = e^{-ig\lambda_{\mu\nu}(x_\mu)\sigma^{\mu\nu}}\xi_\mu \tag{40}$$

$$\begin{aligned}\partial_\mu \to \partial_\mu &- ig\partial_\mu\lambda_{\mu\nu}(x_\mu)\sigma^{\mu\nu} \\ &= \partial_\mu + \partial_\mu \log \Lambda\end{aligned} \tag{41}$$

$$\begin{aligned}\Gamma_\mu \to \Gamma_\mu &+ ig\partial_\mu\lambda_{\mu\nu}(x_\mu)\sigma^{\mu\nu} \\ &= \Gamma_\mu - \partial_\mu \log \Lambda\end{aligned} \tag{42}$$

Where the sign change comes from the fact that the covariant correction operates on γ^ν while Λ operates on ξ_μ. Hence this is equivalent to changing the order in the commutator and hence there exists a change in sign, and the transformation has opposite differentials with ∂_μ and Γ_μ. The form of the covariant differential D_μ is thus left intact by gauge transformations with the spin curvature connection, and the wavefunction is separably transformed from that of γ^ν. The adjoint wavefunction is with the conjugate of this wavefunction transformation, so the probability amplitude is left unaffected in the Dirac equation, and the electromagnetic gauge connection may be added separately. Thus the net covariant differential is:

$$D_\mu = \partial_\mu + \Gamma_\mu + \alpha A_\mu \tag{43}$$

Lagrangian for SC

For the sake of gauge invariance the QED Lagrangian it is posited must now be updated to:

$$\begin{aligned}\mathcal{L}_{SC} &= \bar{\psi}(i\hbar c\gamma^\mu D_\mu - mc^2)\psi \\ &- \frac{1}{4\mu_0}F^{\mu\nu}F_{\mu\nu} + \kappa\Omega^{\mu\nu}\Omega_{\mu\nu}\end{aligned} \tag{44}$$

Where:

$$D_\mu = \partial_\mu + \Gamma_\mu + \alpha A_\mu \tag{45}$$

And:

$$\alpha = \frac{e}{\hbar c} \qquad \Gamma_\mu = \partial_\mu \log \gamma^\nu \tag{46}$$

And the curvature of the antiferromagnet (or ferromagnetic) field is:

$$\Omega_{\mu\nu} = \partial_\mu \Gamma_\nu - \partial_\nu \Gamma_\mu \tag{47}$$

In analogy with the electromagnetic field tensor. We will now show this reduces to a version of our original Lagrangian for antiferromagnetism in the equations of motion. What is to note about this Lagrangian is that the γ^μ one-forms carry spatiotemporal dependence.

Transformation With an Electromagnetic Field

Beginning with the reciprocal property of γ^μ and D_μ we derive the response from this condition extending to the introduction of an external four potential αB_μ. The given is that:

$$\gamma^\mu D_\mu \xi_\mu = \xi_\mu \tag{48}$$

It is illuminating to consider the torsion property as related to the Meissner effect.

Then we add $\alpha B_\mu = f_\mu$ to produce the new condition, interrelating the accelerated frame transformation produced under interaction to the addition of this field:

$$\lambda^\mu \gamma^\mu (D_\mu + f_\mu)\xi_\mu = \xi_\mu \tag{49}$$

So that to satisfy both equations:

$$\lambda^\mu \gamma^\mu (D_\mu + f_\mu) = \gamma^\mu D_\mu \rightarrow \tag{50}$$

$$\lambda^\mu = (\gamma^\mu D_\mu + \gamma^\mu f_\mu)^{-1} \gamma^\mu D_\mu \tag{51}$$

The partial derivative and spin curvature terms are modified as the following:

$$\partial_\mu \rightarrow \partial_\mu + \partial_\mu \log \lambda^\mu \qquad \Gamma_\mu \rightarrow \Gamma_\mu - \partial_\mu \log \lambda^\mu \tag{52}$$

With this, the covariant differential is preserved. The added term comes from the distributive property of the $\log$ function and the action of the transformation on the wavefunction:

$$\partial_\mu \log \lambda^\mu = \partial_\mu \log((1 + \gamma^\mu f_\mu)^{-1}) = -\gamma^\mu \partial_\mu f_\mu \tag{53}$$

Since they are in the same frame, γ^μ and ∂_μ commute. Integrated as a source this term is:

$$-f_\mu = -\alpha B_\mu \tag{54}$$

The added term of λ^μ perfectly compensates for the added f_μ by the above. Hence the electromagnetic potential that is applied causes a shift of energy momentum between the two parts of orbital and spin curvature energy momentum, at the strength of the applied electromagnetic potential.

The condition of (45), implies that from the perspective of a particle accelerated in relation to a particle at rest, the particle at rest acts as a source generating an opposite potential to its own potential as experienced in the frame of the accelerated particle. The accelerated particle is not a source to itself because of the reciprocal condition and it is at rest in its frame, so it experiences the (negative) potential of the other particle at rest. This indirect potential acts on either particle, and must act to attract them, and a gap develops.

As there exists a frame of rest and condition (45) is conserved under a frame transformation, there exists no direct potential, but there does exist one arising from the frame of acceleration relative to the frame of rest, as a back reaction reversed potential on the particle in the accelerated frame.

Thus both particles experience a negative potential with respect to the other particle, which is the following potential:

$$\int \gamma^\mu \partial_\mu \log \lambda^\mu dx^\mu = -\alpha B_\mu \tag{55}$$

This explains the diamagnetic effect and pairing, and is consistent with the magnetic field being zero. Additionally, the magnetic field of zero can be explained as the fact that if γ^μ and D_μ operating on ξ_μ are reciprocal to a constant, and given the momentum is inertial, it produces zero magnetic field in all frames.

But this condition of the eigenstate is preserved with respect to all frames, thus the magnetic field is globally zero for all points within the material.

Covariant Differential Commutation Relationship

Consider the interior transformation of the covariant differential due to the term produced by the previous transformation under action of the electromagnetic field:

$$
\begin{aligned}
& [D_\mu, D_\nu] \quad (56)\\
&= \partial_\mu\partial_\nu + \partial_\mu\Gamma_\nu + \Gamma_\mu\partial_\nu + \Gamma_\mu\Gamma_\nu \\
&-\partial_\nu\partial_\mu - \partial_\nu\Gamma_\mu - \Gamma_\nu\partial_\mu - \Gamma_\nu\Gamma_\mu \\
&\to (\partial_\mu - \alpha\partial_\mu A_\mu)(\partial_\nu - \alpha\partial_\nu A_\nu) \\
&-(\partial_\nu - \alpha\partial_\nu A_\nu)(\partial_\mu - \alpha\partial_\mu A_\mu)) \\
&+(\partial_\mu - \alpha\partial_\mu A_\mu)(\Gamma_\nu + \alpha\partial_\nu A_\nu) \\
&-(\partial_\nu - \alpha\partial_\nu A_\nu)(\Gamma_\mu + \alpha\partial_\mu A_\mu) \\
&+(\Gamma_\mu + \alpha\partial_\mu A_\mu)(\partial_\nu - \alpha\partial_\nu A_\nu) \\
&-(\Gamma_\nu + \alpha\partial_\nu A_\nu)(\partial_\mu - \alpha\partial_\mu A_\mu) \\
&+(\Gamma_\mu + \alpha\partial_\mu A_\mu)(\Gamma_\nu + \alpha\partial_\nu A_\nu) \\
&-(\Gamma_\nu + \alpha\partial_\nu A_\nu)(\Gamma_\mu + \alpha\partial_\mu A_\mu) \\
&= -\alpha\partial_\mu A_\mu D_\nu + \alpha\partial_\nu A_\nu D_\mu \\
&+\partial_\mu D_\nu - \partial_\nu D_\mu \\
&+\alpha\partial_\mu A_\mu D_\nu - \alpha\partial_\nu A_\nu D_\mu \\
&+\Gamma_\mu D_\nu - \Gamma_\nu D_\mu \\
&= \partial_\mu D_\nu - \partial_\nu D_\mu + \Gamma_\mu D_\nu - \Gamma_\nu D_\mu \\
&= D_\mu D_\nu - D_\nu D_\mu = [D_\mu, D_\nu]
\end{aligned}
$$

Which indicates that the two gauges are mutually satisfied under transformation by the field, interior to the covariant differential. This also holds true for the total covariant differential since any transformation should be performed symmetrically. Hence, the commutation relationship of the covariant differentials is preserved under the internal transformation of its terms. Furthermore:

$$[D_\mu, D_\nu] = -[\Lambda^\mu_\nu D_\mu, \Lambda^\nu_\mu D_\nu] = -[D_\nu, D_\mu] \quad (57)$$

Indicating the commutation relationship is antisymmetric under a symmetric frame transformation. We may evaluate this term in the following way at a point in space:

$$
\begin{aligned}
& \xi_\mu\xi_\nu[D_\mu, D_\nu]\xi_\mu\xi_\nu \quad (58)\\
&= \xi_\mu\xi_\nu(D_\mu D_\nu - D_\nu D_\mu)\xi_\mu\xi_\nu \\
&= -\xi_\mu\xi_\nu(\Lambda^\mu_\nu D_\mu \Lambda^\nu_\mu D_\nu - \Lambda^\nu_\mu D_\nu \Lambda^\mu_\nu D_\mu)\xi_\mu\xi_\nu \\
&= -\xi_\mu\xi_\nu(D_\mu \log\Lambda^\nu_\mu D_\nu - D_\nu \log\Lambda^\mu_\nu D_\mu)\xi_\mu\xi_\nu \\
&= -\xi_\mu\xi_\nu(\gamma^\nu\partial_\mu \log\Lambda^\nu_\mu D_\nu - \gamma^\mu\partial_\nu \log\Lambda^\mu_\nu D_\mu)\xi_\mu\xi_\nu \\
&= -\xi_\mu\xi_\nu(\gamma^\mu\partial_\mu \log\Lambda^\nu_\mu - \gamma^\nu\partial_\nu \log\Lambda^\mu_\nu)\xi_\mu\xi_\nu \\
&= -\xi_\mu\xi_\nu\alpha(\partial_\mu A_\nu - \partial_\nu A_\mu)\xi_\mu\xi_\nu \\
&= -\xi_\mu\xi_\nu\alpha F_{\mu\nu}\xi_\mu\xi_\nu
\end{aligned}
$$

Making use of (34) and γ^μ and γ^ν to correct for the covariant differential making it a partial derivative by (35) and the fact that when the partial derivative associated spin is multiplied by another spin factor the negative logarithmic derivative is introduced into the equations (37) and (38). Hence:

$$[D_\mu, D_\nu] = -\alpha F_{\mu\nu} \quad (59)$$

The spin field transformation which accompanies the introduction of the electromagnetic field, under the covariance of the form of the eigenstate is a curved transformation of coordinates, and hence what we arise at is a real consequence of coordinates. It is flat in a sense (when one accounts for the change in coordinates) and curved in a sense (when one does not account for this change in coordinates) naturally. The Meissner effect is seen as the conventional departure of the electromagnetic field tensor torsion condition at the boundary of the superconductor.

Calculation of Exchange

We can now proceed to analyze the commutation relationship of the ∂_α and Γ_α with the added $\pm\Lambda_\alpha$. Under the two particle equation this is reversed in sign among the two sides of the two particle Dirac equation corresponding to particle 1 and particle 2. Under consideration of the fact that Λ_α changes sign under juxtaposition.

Exchange Difference Hypothesis: *The added logarithmic differential of the frame transformation, or its curvature, Λ_α, in changing sign between frames behaves in conjunction with ∂_α and Γ_α as raising and lowering operators in the two particle Dirac equation.*

To test this hypothesis consider the ∂_α energy momentum for the singlet. Between states in the two particle Dirac equation a term enters as:

$$
\begin{aligned}
& (-i\hbar\partial_\alpha + 2\hbar\Lambda_\alpha)(-i\hbar\partial_\alpha - 2\hbar\Lambda_\alpha)\Psi \quad (60)\\
&= -2\hbar^2(a^\dagger a)\Psi \\
&= -2\hbar^2\partial_\alpha\Lambda_\alpha
\end{aligned}
$$

The term on the spin curvature enters as:

$$
\begin{aligned}
& (-i\hbar\Gamma_\alpha - 2\hbar\Lambda_\alpha)(-i\hbar\Gamma_\alpha + 2\hbar\Lambda_\alpha)\Psi \quad (61)\\
&= -2\hbar^2(aa^\dagger)\Psi \\
&= -2\hbar^2\partial_\alpha\Lambda_\alpha
\end{aligned}
$$

Thus the effect of the acceleration and the existing momenta, create the conditions under the two body (with opposite accelerative frame boosts) of anticommuting operators. The two particle equation is the product of two Dirac equations acting on the superposition of the two wavefunctions, here taken in the center of mass frame α:

$$(\gamma^\alpha(-i\hbar\partial_\alpha - i\hbar\Gamma_\alpha + eA_\alpha) - m) \quad (62)$$
$$(\gamma^\alpha(-i\hbar\partial_\alpha - i\hbar\Gamma_\alpha + eA_\alpha) - m)\xi_\alpha^- \xi_\alpha^+ = 0$$

Substitution of conserved quantities to simplify the calculation results in:

$$(-i\hbar\eta_+^\alpha + e\sigma^\alpha - m) \quad (63)$$
$$(-i\hbar\eta_-^\alpha + e\sigma^\alpha - m)\xi_\alpha^- \xi_\alpha^+ = 0$$

Because the positive and negative orbital momentum and spin curvature sum to zero:

$$(e^2\sigma^\alpha\sigma^\alpha - (me + 2ie\hbar(\eta_+^\alpha + \eta_-^\alpha))\sigma^\alpha \quad (64)$$
$$+im\hbar(\eta_+^\alpha + \eta_-^\alpha) - \hbar^2\eta_+^\alpha\eta_-^\alpha + m^2)\xi_\alpha^- \xi_\alpha^+ = 0$$

Because the only term which contributes to the change from the singlet to triplet under the change in sign by the operators above is η^α and $\eta_+^\alpha + \eta_-^\alpha$ is zero by equal and opposite momenta, this reduces to:

$$-4\int\int \xi_\alpha^+ \xi_\alpha^- \hbar(\eta_+^\alpha\eta_-^\alpha \quad (65)$$
$$-\eta_-^\alpha\eta_+^\alpha)\xi_\alpha^- \xi_\alpha^+ dx^\alpha dx^\alpha = \Delta$$

η^α produces four terms which obey a commutation relationship by way of the above:

$$\begin{aligned} &\eta_+^\alpha\eta_-^\alpha - \eta_-^\alpha\eta_+^\alpha \quad (66)\\ &= (\partial_\alpha^+ + \Gamma_\alpha^+)(\partial_\alpha^- + \Gamma_\alpha^-)\\ &-(\partial_\alpha^- + \Gamma_\alpha^-)(\partial_\alpha^+ + \Gamma_\alpha^+)\\ &= (\partial_\alpha^+\partial_\alpha^- + \partial_\alpha^+\Gamma_\alpha^-\\ &+\Gamma_\alpha^+\partial_\alpha^- + \Gamma_\alpha^+\Gamma_\alpha^-)\\ &-(\partial_\alpha^-\partial_\alpha^+ + \partial_\alpha^-\Gamma_\alpha^+\\ &+\Gamma_\alpha^-\partial_\alpha^+ + \Gamma_\alpha^-\Gamma_\alpha^+)\\ &= -4\partial_\alpha\Lambda_\alpha + ([\partial_\alpha^-, \Gamma_\alpha^+] - [\partial_\alpha^+, \Gamma_\alpha^-])\\ &= -4\partial_\alpha\Lambda_\alpha \end{aligned}$$

Where the following equality holds:

$$[\partial_\alpha^-, \Gamma_\alpha^+] = [\partial_\alpha^+, \Gamma_\alpha^-] \quad (67)$$

As the extra Λ_α changes sign *with* the derivative, leaving for the two particle energy gap *for all electrons*:

$$\Delta = 4\hbar c\int \gamma^\alpha\Lambda_\alpha dx^\alpha \quad (68)$$
$$\equiv 4e\int \gamma^\alpha A_\alpha dx^\alpha = 4J$$

This last equivalence is because in the exchange interaction the terms of μ and ν are juxtaposed and appear in the Λ, which by the previous section is equivalent to an electromagnetic potential differential. This is consistent with the previous section, where a γ^ν changes in a *relative* manner such that a reversed A_ν is generated for the particles in motion *within a spin system background.*

If the particles are relatively accelerated there exists a reversed potential between them with an energy lowering that is the contribution to their energy from this potential, and it is equivalent to an energy mass lowering of their inertial content. This is true as the acceleration gives rise to the (reversed) potential and without an acceleration there exists no potential. The acceleration as a source for the potential is physically equivalent to the lowering of the inertial mass energy, since it is the same term numerically.

This is fundamentally the expression that the potential energy mass lowering as sourced in the acceleration, and numerically equivalent with the inertial mass energy lowering, is a matter of frame, and the two are equivalent between all frames, hence the lowering is a prediction of general covariance. Since the quantum singlet to triplet operator holds individually between particles and a conventional to ultimate difference is taken the lowering holds for all two particle states. This implies the following equivalence:

Quantum Equivalence Principle: *The potential mass energy lowering is indistinguishable from the inertial mass energy lowering.*

Discussion of Energy Lowering

This seems in conflict with some of our intuition regarding the changing of forms of energy, for it seems as if we should require that:

$$\Delta(PE + KE) = 0 \quad (69)$$

By energy conservation. However, in the inertial frame it holds true that:

$$\Delta PE = \Delta KE = 0 \tag{70}$$

The condition of general covariance and its identity implies however that:

$$\Delta PE = \Delta KE \neq 0 \tag{71}$$

For now, imagine an Earth-Sun system, in which we boost into an accelerative frame with equivalent acceleration to that of the Earth about the Sun. It is not that we experience a lowering of mass below the rest mass for the Earth, but that it 'returns' to rest mass energy content. In and by way of this it does indeed lower, but it is a matter of perspective. Going back to the system so established, we ask the question as to whether both energy conservation and general covariance can be satisfied with the formalism developed.

The analogy is actually quite simple, for what happens is that from the distant and stationary observer it appears that:

$$\Delta PE = \Delta KE < 0 \tag{72}$$

The interpretation of this is merely that by general covariance relativistic factors return to unity for the system such that the quantization condition relative to an observer which is moving in relation to the superconducting quantum state, is perceived as a system in motion where the quantization condition is one of the inertial variety and thus of a lowered energy relative to the observer. In this a very real energy momentum lowering has occured by the above and the condition of general covariance. The quantum equivalent of the Earth-Sun system is to see that it is the inertial constraint on quantum exchange we judge as non-inertial when it is in fact quantized inertially. This admits the formation of a new conclusion regarding quantum phenomena in general, as for example the photoelectric effect by which a photon is absorbed by an electron and knocks it out of its orbital in a metal, past a threshold energy momentum:

Conclusion: *The general statement is that relative to an accelerated observer there exists an energy mass gap because the quantum state is quantized subject to an inertial frame condition by the presence of the principle of general covariance within quantum mechanics. From this, the proper way to account for quantum motion is such that it is taken as a given inertial. A physical gap exists because the quantum state is quantized under the inertial condition, and yet what we measure is the accelerated interpretation of this state. This gap is real by observation from the indistinguishability of the inertial and potential relativistic factors under the equivalence principle for any transition of a quantum nature.*

Distinction

While an interaction takes place, it is true that the uncertainty principle would be modified in the observables not for the sole reason that the coordinates change under acceleration, for there does exist a coordinate free representation of the observables compatible with acceleration such that the uncertainty principle is satisfied. It it also because either:

A:) *If the electromagnetic interaction is not included in the momentum then it modifies the position and momentum compatible with an acceleration and an interaction that varies, and thus the relative determination of momentum and position is functional and dependent on coordinates, and not an invariant description, given that this acceleration exists in a way that is dependent on coordinates with respect to the operation of position of one particle upon the momentum of another, and with the reverse operation. Hence a coordinate dependent anomaly arises in the commutation relationship between the observables of different particles, whenever the electromagnetic potential is not included in the particle description.*

B:) *If the electromagnetic interaction is included then the former anomaly does not occur, because the commutation relationship is perfectly compensated for in its change with respect to the quantities of particle momentum and field momentum, as one merely changes the other in an equal and opposite functional manner and they are comparatively added instead of a complimentary change absent.*

Conclusion: *What can be seen is that it is the sum of these changes which is the expression of a net invariance of the determination of the uncertainty principle with respect to the general covariance of the observables without which there is no commutation of the separable momenta or positions.*

If and only if this holds true can we satisfy both postulates. The restriction to mutually satisfying both postulates is trivial without invoking the multiparticle viewpoint but not when it is invoked. For note that the uncertainty principle can be made invariant by a generally covariant coordinate basis locally.

However, this is not manifestly globally invariant in that the determination of the multiparticle relationship of uncertainty does not mutually commute between different particle observables, for the same reason there exist different coordinate systems for different particles.

Additionally, although with an interaction, the single particle uncertainties remain manifestly locally invariant, they are not as determined globally in the sense of between particles, unless the interaction potential is included in the momentum. When the interaction is included the change it introduces compensates for changes in the particle momentum in such a manner that the system is manifestly generally covariant and the uncertainty principle is left generally invariant.

For this to be true an identity must hold true between the frame transformation and electromagnetic field interaction, namely that the log differential of the frame transformation is the negative of the log differential of the electromagnetic field tensor, weighted by the appropriate constant (α):

$$\partial_\mu \log \Lambda^\nu_\mu = \alpha \partial_\mu \log F^{\mu\nu} \tag{73}$$

Furthermore this identity gives a relationship to the description of the frame as it covaries with the particle description of momentum, and yields the total covariantly conserved quantity of momentum. It is merely the force law ($F = ma$), by inspection.

Justification and Ramifications

First to note is that the multiparticle perspective is one to one with the existence of interactions, which by way of and which there exists a connection to the differing frames of acceleration, and that these interactions must be included as a field potential energy momentum as it pertains to the full particle energy momentum as an observable in order for there to be a commutation relationship consistent with the uncertainty principle between the observables of the multiple particles.

This is to satisfy the uncertainty principle with respect to the different particle's definitions of each other, and their mutual commutation relationships, for their definitions of momentum do not commute when the interaction potential is left out. Additionally, what is striking is that it is the full particle and field energy momentum as carried by the particle that defines the observable and it is not particle only.

This seems to express on a base level that it is the full particle energy momentum with field that becomes the observable in the multiparticle viewpoint, as such must be the case to satisfy the uncertainty principle with general covariance resulting from changes in the coordinates with respect to the frame of motion, resulting from and identifiable with the acceleration due to the interaction.

As a consequence, the eigenstate condition of the Dirac equation is intact, although there is a slight difference in interpretation, arising in the context of the multiparticle description. For instance, the equation:

$$(i\gamma^\mu(p_\mu + \alpha A_\mu) - mc)\xi_\mu = 0 \tag{74}$$

Is the expression of the eigenstate condition of a particle like an electron. Although the single particle description of the eigenstate does not differ when mapped from the multiparticle condition, what remains to be seen is if the condition this represents mathematically is still identifiable with what it means in the multiparticle interpretation.

For while the Dirac equation, as it was initially interpreted, holds perfectly well with the condition of an ordinary partial derivative upon it being zero to result in an eigenstate, there is a subtle difference in the multiparticle setting with general covariance. Here, the condition is that the total covariant differential defined as:

$$D_\mu = \partial_\mu + \Gamma_\mu + \alpha A_\mu \qquad \Gamma_\mu = \partial_\mu \log \gamma^\nu \tag{75}$$

Must be used in place of:

$$p_\mu + \alpha A_\mu = \partial_\mu + \alpha A_\mu \tag{76}$$

In the generally covariant setting. With this, although the Dirac equation is left locally intact, given that

Γ_μ vanishes locally, it does not vanish identically for particle to particle comparisons. To prove this all it suffices to say is that the connection described in equation (8) is preserved under relative comparison of observables, and hence in general, or as for the multiparticle description, since Γ_μ does not vanish globally and must be included for generality.

As a final note consider that locally the description remains the same for the single particle description, for all particles, but that the multiparticle description differs substantially, as for instance γ^μ also takes on structure of the form of a function, and the descriptions may be inequivalent physically:

Hypothesis II: *The physics of the multiparticle description differs from the single particle description.*

In the case of exchange this can be an energy lowering. To note then is that this can lead to a collectively lowered energy in the case of superconductivity.

Examining superconductivity, for instance, the mystery is:

Mystery: *How does the energy lower, even if only in relative terms?*

This is only possible in a relative sense if the physical quantum description changes, and if the potential and kinetic energy both lower. But, the change between the singlet and triplet can be relatively modified by a matter of perspective. Internally to the system there is no change in kinetic energy as indicated by the field to frame relationship in the inertial frame, but observationally, it appears that there is a gap in energy.

To note then is merely that the triplet and singlet are repulsive and attractive, and therefore possess opposite relative curvatures, which immediately indicates a subjective-objective agreement of an energy difference of $2J$ per particle, because relatively there also exists an energy difference in the kinetic energy of J in the inertial mass energy by this same curvature relative to a system at rest external to it.

From the constraint of equation (43) and that which is imposed by the existence of multiple particles for which the condition of general covariance must be satisfied, the exchange phenomenon is relative and reveals a mass energy gap.

To prove this result quantitatively and rigorously one needs to evaluate the net integral, but this value is given empirically by the relation encoded in equation (44), which says that the differentials of these quantities are identical up to a constant of proportionality, and that their integrals should be equivalent up to a constant of integration. Then, because of this identity, the mass gap for an external observer outside the system, is the entire exchange energy difference of the two particles measured in the system of J with the change of the kinetic mass energy of J for a total of $2J$ per particle in sum.

In this context, the exchange is real only when observed from outside the system, and it is purely a relative phenomenon. Carefully noting their natures, that one is an electromagnetic potential energy difference when integrated, and that the other is an inertial mass energy difference when integrated, we arrive at the following conclusion:

Conclusion: *Relative potential and inertial mass energy lowerings are indistinguishable.*

However the gap must be weighted by the appropriate Lorentz factor, and this gives the formula and equivalence:

$$\begin{aligned}\Delta &= 4\hbar c \int_\tau \gamma^\mu \partial_\mu \log \Lambda^\nu_\mu dx^\mu \\ &= 4e \int_\tau \gamma^\mu A_\mu dx^\mu = 4J\end{aligned} \tag{77}$$

Mystery Revisited

The first thing of note in resolving this mystery is that the interpretation of the Meissner Effect is the confluence of the principle of general covariance and the uncertainty principle. The physics does not change, merely the interpretation of the uncertainty principle. The two statements, one of the Meissner Effect, and secondly, one of energy conservation, are respectively the instantiation and extension of the uncertainty principle and general covariance. For instance, examining the equal and opposite fields which are one to one with spin angular momentum as mutual observables, is a manifestation of the uncertainty principle to say they do not depart from commutativity with respect to boosts.

Secondly, energy conservation here is a principle by which the only dependence of this equal and opposite magnetic field is upon the perceived metrical relationship due to motion, otherwise the gravitational field of the body would change and they would exchange an extra contribution of energy, and would not preserve the center of mass under freefall.

In showing by contradiction (of a dual nature) that one or the other of these principles is violated if and when the transformation is not reciprocal to the field, one shows that the Meissner Effect is a generally covariant uncertainty principle based phenomenon. This is one to one with the principle by which the fields are in inverse or reciprocal relationship to the relativistic transformation, and:

This follows from the indistinguishability of the inertial and potential relativistic factors.

What is known is that the covariant differential in total does in fact commute, and that when it is separated into particle and field momenta that these do not commute. Thus this implies a number of things. First of all is that it is only the total field and particle momentum which is inertial, which is the interpretation of the Meissner Effect.

Secondly is that the four momentum of the particle alone is curved with respect to the field of electromagnetism alone. This is consistent because this leads to the condition of equivalent and opposite functional curvature relationships for these substituent quantities. Lastly, what this implies is that it is indeed true that the potential mass energy lowering in a superconductor is fundamentally indistinguishable from the inertial mass energy lowering.

From this follows the generalization of the condition implied by the first section of this paper, which is that:

$$D_\mu(i\gamma^\mu(p_\mu + \alpha A_\mu) - mc)\xi_\mu = 0 \tag{78}$$

Which is nothing other than the condition for a covariant eigenstate.

As an experiment simply consider dropping a superconductor levitating a magnet, if this theory holds true then because there is a gradual change in the gravitational frame, as they fall their curvatures should contribute equally, with the prediction that the initial condition requires that they will fall together as one, given their mutual inertial relationship in an approximately inertial frame.

Conclusion: *There is a measurable and physical effect on the interpretation of the observables in the uncertainty principle given their coordinate system and frame independence.*

Interdependence of Orbital and Spin Momentum

To explain exactly what 'reciprocity' means in this context, consider the particles. In the two particle Dirac equation, there occurs an *internal* reciprocation of spin curvature energy momentum and orbital energy momentum. This occurs **not** because the particles merely *influence* each other, but because they *influence each other's representations* in particle energy momentum and spin curvature energy momentum to change. Hence the wavefunctions in remaining Lorentz invariant *remain the same physically*, but there occurs a reciprocation between the quantum and the relativistic *components* of the objects.

Now consider that given the Dirac equation holds for one particle. Any multiparticle modification of dynamics must occur internal to the equation, and not modify its overall structure, but it **can** modify the individual terms in a plus-minus like fashion. This is a way to side step the problem of coming up with a new and unique generalized transformation, analogous to the γ^μ, which will encode a curved space *in general.* In this way, the multiparticle and accelerative features of reality are encoded in changes of the components of the representation. This represents something wholly new however, because the old addage that '*the whole is greater than the sum of it's parts*' applies. In this, the particles are **not** moving through each other merely because something only akin to a potential holds between them, but because a *change in each other's representations* arises from their mutual quantum and relativistic *relationships.*

An Instance of Reciprocity: *Reciprocity here means the comparison of different accelerative frames under the* *singlet and triplet, in which acceleration contributes to the spin curvature and orbital energy momentum, causing the two parts of the representation: the orbital and the spin, to reciprocate in space and time such that the particles mutually lower in energy and oscillate in space and time.*

Λ_ν is added and subtracted merely because of the rule of general covariance, and through quantum mechanics produces a reciprocation of accelerative spin curvature energy momentum and accelerative orbital energy momentum, so that the above can be put more simply:

Reciprocity Generalized: *Relative comparison of different quantum states under superposition leads to an energy difference in the states when different observable frames of acceleration are also compared.*

The emphasis in general is that **both** different relativistic frames of acceleration **and** different quantum states are compared simultaneously. Taking as the displacement the energy momentum associated with the change due to the difference of frames under an accelerative boost, afforded by the addition of an inertial interaction of the electromagnetic field:

$$\Lambda_\nu = \partial_\nu \log \Lambda^\mu_\nu \tag{79}$$

Because of the equivalency principle, Λ_ν is zero in the frame of the particle and *does not* contribute to the single particle description. While for the *comparison* of states in the singlet and triplet where different frames of acceleration are compared the contribution from the relativistic frame of acceleration *difference* leads to a *displacement* of $\pm\Lambda_\nu$. The essential idea is that the gap and attractive force arises from the qualitative difference between the single particle and two particle pair descriptions under the singlet and triplet. This makes for an interaction that results in a distinction that must be made between a particle in the single particle description, and a particle that is a *part* of a two particle state under mutual *acceleration.*

When the particles are put together they produce a qualitatively different result from only the single particles put together with only an electromagnetic interaction. For instance, under exchange, interchange of frames: $\mu \leftrightarrow \nu$ creates a $\pm\Lambda$ relativistic frame difference on ∂ and Γ.

Hence reciprocation is predicted with exchange, along with an energy difference of the singlet and triplet. This implies that reciprocation of quantities is one to one with inertial motion and this is one to one with an inertial electromagnetic force, which is in turn one to one with the Meissner Effect. However, the energy of the total system is lowered or raised under mutual acceleration by the presence of the extra Λ_ν which leads to the different momenta as operators producing an algebraically different result from their simple sum when operating on the wavefunction.

Hence, inertial motion is consistent with conservation of the exchange energy (through the cancellation of the distance dependence and inertial quality of the electromagnetic force) and reciprocation of spin and orbital degrees of freedom. We can conclude from the mere fact that spin-orbital reciprocation takes place that the exchange energy is conserved and one to one with the initial statement that the equivalency principle holds for the force law holding the charges together.

Hence, a non-dynamical difference in the exchange energy can be seen as an outcome of the inertial property, or the inertial property holding true can be seen as an outcome of the exchange energy developing a difference, but neither can be proven entirely by independent means. Finally to note is that this has an implication for general relativity as a reaction, for when the transition to the superconducting state takes place its mass lowers, invoking a complimentary raising of general relativistic energy.

This, in its general form, is what reciprocity means in the end. For the gestalt picture of quantum mechanics and general relativity produces changes in each, which are complimentary, because the general relativistic modification of the quantum description, lowers the quantum energy, and it raises itself.

Pairing and Condensation

The connecting principle that implies Δ_p is at a maximum when Δ_c goes to zero, and vice versa can be explained by two facts:

1.) *When particles fall into pairs they become more localized in the orbital degree of freedom, hence their relationship to one another is a* ***larger boost apart*** *be-*

tween the holes comprising distinct pairs.

2.) *The electrons and lattice* ***counteract*** *both the condensation and pairing with a resistence to an expansive force at low doping and to a contractive force at high doping. The electron sea and lattice that exists works against pairing and condensation, while remaining of equal localization to the holes.*

The density of electrons exists in proportion to the localization of holes and electrons (or inverse to their spread) and hence is also proportional to pairing strength. Simultaneously, the outward force of the pairs accelerates them apart, leading to a condensation strength that is proportional to the density of holes.

Thus the inter-pair boost is largest when the density of holes is large, explaining a large condensation gap at high doping, and the inter-hole boost is largest when the density of electrons is large, explaining a large pairing gap at low doping. Hence the two processes of balanced forces and distinct effects of the electrons or holes are at odds, yet the force inwards must balance the force outwards.

As a consequence there exists a range of doping intermediate between the extremes where superconductivity exists and it must fall off to both sides like a semicircle reaching zero because the electrons and lattice counteract the condensation force at low doping with a net contractive force of electrons with the lattice, and pairing force at high doping with an expansive force due to the large number of holes.

Since condensation may be treated as the change in orbital localization due to relative frame, and pairing may be treated as the accelerative parameter due to the localization (inverse to the spread of the wavefunction), the net effect is described by the energy lowering being the contracted factor of:

$$\begin{aligned} \Delta &= 4\hbar c \int_\tau \gamma^\mu \partial_\mu \log \Lambda^\nu_\mu dx^\mu \\ &= 4e \int_\tau \gamma^\mu A_\mu dx^\mu = 4J \end{aligned} \tag{80}$$

This is because the factor of Λ_ν is the factor corresponding to the boost leading to pairing, and γ^ν corresponds to the *excess* energy lowering from relative frame due to change in the boost parameter by acceleration into pairs. This is thus a factor multiplying the accelerative frame difference corresponding to the pair energy as a relative boost between pairs of the condensate. If it goes to unity then the energy of the condensation gap is zero, while if the acceleration goes to zero then pairing vanishes. Everywhere the gap is the constant of $4J$. This interval of superconductivity occurs when the lattice plus the electrons that exist balance the force outwards of the condensation and the force inwards of the pairing, but since the force is nonzero, and it acts through a distance by the effect of length contraction, the holes experience a net energy lowering intrinsic to the material.